B. <u>Specification</u>

Please amend the paragraph at page 1, lines 6-11, as follows:

--The present invention relates to a chemical sensor and a chemical sensor apparatus~~, and particularly~~<u>. In particular, it</u> relates to a chemical sensor and a chemical sensor apparatus<u>,</u> including a biosensor<u>,</u> for use in medical ~~cave~~<u>care</u>, ~~a~~ health examination, food evaluation, etc.--

Please amend the paragraph at page 1, line 21, to page 2, line 3, as follows:

--Further, a sensor ~~which realize~~<u>that can provide</u> further integration ~~and~~ <u>at a</u> low production cost and can be used in any measurement environment~~,~~ is required. ~~As the~~<u>A most promising</u> sensor~~,~~ <u>is</u> a biosensor using surface plasmon resonance as a transducer ~~is most promising~~. The biosensor detects whether there ~~arises~~ <u>is</u> adsorption of a substance, such as an antigen in an antigen-antibody reaction, by using ~~the~~ surface plasmon resonance generated in a thin metal film disposed on a surface of a total (internal) reflection-type prism.--

Please amend the paragraph at page 2, lines 11-19, as follows:

--However, in the ~~above~~ <u>above-</u>described surface plasmon resonance sensor, various trials for realization of high sensitivity, such as reduction in noise of a light source and detection signal processing, have been ~~made~~<u>conducted</u>. However, as medical care, ~~a~~ health examination<u>,</u> or food evaluation ~~becomes~~ <u>reaches</u> a higher level, ~~a further high~~ <u>an</u>

even more sensitive chemical sensor is required. As a result, realization of high sensitivity has been approaching its limit.--

Please amend the paragraph at page 2, lines 22-24, as follows:

--An object of the present invention is to provide a chemical sensor capable of further improving sensitivity of a sensor ~~sensitivity~~.--

Please amend the paragraphs at page 3, line 18, to page 5, line 23, as follows:

--As described above, the present invention is characterized in that the period of the periodic structure is substantially identical to an integral multiple of a wavelength of the surface plasmon polariton wave (hereinafter referred to as the "SPP wave") generated at an interface between the periodic structure and the sensor material. As the periodic structure, for example, it is possible to use a small opening array or a small uneven structure array disposed on the thin metal film described above or ~~a fine~~fine metal particles disposed on a substrate. It becomes possible to realize a high-sensitivity chemical sensor by causing light to enter the periodic structure and detecting its transmitted light or its reflected light.

For example, in the case of the small openings formed on the thin metal film, the SPP waves propagated along an upper surface of the thin metal film in an in-plane mode have the same phase in a resonance-~~enhancedly~~ enhanced manner to increase their

amplitudes, thus being concentrated at the small openings. Accordingly, the transmitted light generated by scattering of the incident light at a lower portion of the small openings principally comprises a component attributable to the SPP waves propagated along the upper surface of the thin metal film in an in-plane mode over a longer distance, compared with a component of light directly incident on the small openings and transmitted therethrough. The SPP waves are accompanied ~~with~~ by a change in the dielectric constant or thickness of the sensor material, i.e., a change in wavelength depending on a degree of a reaction of the sensor material with the specimen, at the time of propagation through the interface between the thin metal film and the sensor material. Accordingly, it is possible to selectively detect the component attributable to the SPP waves having information on the degree of a reaction of the sensor material with the specimen by detecting the ~~above~~ above-described transmitted light. As a result, it becomes possible to realize detection at a high sensitivity.

Further, for example, by providing a length of the circumference (circumferential length) of a thin metal film portion between adjacent two openings so as to be substantially an integral multiple of wavelength of the SPP wave, an SPP wave, which is ~~once~~ propagated once on the lower surface side of a thin metal film portion after being passed through a small opening and then returned to the upper surface side of the thin metal film portion through an adjacent small opening, is in phase with an SPP wave propagated along the upper surface of the thin metal film portion in an in-plane mode, so that a height of the resonance peak in a transmitted light intensity spectrum is further

increased, but a width thereof ~~becomes narrower~~is decreased. As a result, ~~an~~ the ~~amount of~~ ~~a~~ change in the quantity of transmitted light ~~quantity~~ with respect to ~~a~~ the change in position of the resonance peak due to a reaction of the sensor material with the specimen ~~becomes larger~~increases, thus further improving ~~a~~ the sensitivity of the sensor.--

Please amend the paragraph at page 7, lines 8-12, as follows:

--In the chemical sensor, the opening and the recess portion or the projection portion may have a substantially circular shape or a substantially polygonal shape, and their periodic arrangements may be ~~a~~ two-dimensional ~~arrangement~~.--

Please amend the paragraph at page 7, lines 16-20, as follows:

--In the chemical sensor, the opening and the recess portion or the projection portion may have a slit-like shape, and their periodic arrangements may be ~~a~~ one-dimensional ~~arrangement~~.--

Please amend the paragraph at page 10, lines 9-12, as follows:

--Figure 4 is a view showing a propagation passage of an SPP wave moving around a thin metal film portion through adjacent small openings in the embodiment of the present invention.--

Please amend the paragraph at page 10, lines 23-27, as follows:

--Figures 8(a), 8(b) and 8(c) are views showing a shape of a pattern array provided on a thin metal film of a sensor medium in ~~EMbodiment~~ Embodiment 2 of the present invention, wherein Figure 8(a) is a sectional view and Figures 8(b) and 8(c) are top views.--

Please amend the paragraph at page 12, lines 3-13, as follows:

--The chemical sensor apparatus includes a sensor material ~~which~~ that contacts a specimen (to be tested) to be reacted with a substance to be ~~detected,~~ detected and a measuring device for measuring a change in sensor material before and after the contact through an optical method or the like. In some cases, the sensor material is separated from the measuring device portion and is subjected to the reaction with the specimen, so that it is held on an appropriate support. Such a structure is referred to herein ~~to~~ as a "sensor medium".--

Please amend the paragraphs at page 13, lines 6-19, as follows:

--Figure 2(a) shows an example of the periodically arranged small openings formed by periodically arranging an array 202 of small slit openings ~~win~~ in an x direction in a thin metal film 201 with each short side in the x direction and each long side in ~~a~~ the y direction. Each of the small openings 103 is a slit-like opening having a length~~,~~ in the y direction perpendicular to the x direction, which is larger than ~~a~~ the width in the x direction.

Further, Figure 2(b) shows an example of the periodically arranged small openings formed by periodically arranging a ~~two~~ two-dimensional array 203 of small openings both in the x direction and the y direction in the thin metal film 201.--

Please amend the paragraph at page 13, line 27, to page 14, line 4, as follows:

--Further, a pitch of the small openings has a value substantially equal to a wavelength of ~~a SPP~~an SPP wave generated at the time of irradiating an interface between the thin metal film 102 and the sensor material 104.--

Please amend the paragraph at page 14, lines 13-27, as follows:

--The sensor material 104 is disposed ~~On~~ on the thin metal film 102~~, the sensor material 104 is disposed~~. The sensor material 104 fixes an objective substance to be detected, which is contained in the specimen, by surface adsorption or chemical bonding when the sensor medium contacts the specimen. Alternatively, the sensor material may be a material constituted by components containing a component ~~which~~ that is bonded to the objective substance to be detected and ~~then~~ is then dissociated from the constitutional components. In this embodiment, the sensor material comprises a material the dielectric constant (refractive index or absorptivity) of which has been changed ~~in its dielectric constant (refractive index or absorptivity)~~ with respect to light by the bonding ~~thereof~~ to the objective substance to be detected or the dissociation of its constitutional component.--

Please amend the paragraph at page 15, line 4, to page 16, line 1, as follows:

--Referring to Figure 1, incident light ~~10~~ 105 is caused to enter the arrangement of the small openings 103 in a downward direction (+z direction) in the drawing. At this time, the incident light is scattered at a corner 107 of the thin metal film 102 facing the small opening 103, whereby an SPP wave is excited at an interface between the thin metal film 102 and the sensor material 104 and is propagated toward a periphery of the thin metal film 102 at an upper surface of the thin metal film 102 in an in-plane mode. At that time, when the pitch P of the periodically arranged small openings 103 coincides with an integral multiple of a wavelength of the SPP wave, the SPP wave is excited at respective corners of the thin metal film 102. The resultant SPP waves propagated in the upper plane of the thin metal film 102 have the same phase to increase their amplitude. As a ~~result,~~result of these SPP waves, a component ~~which~~ that rounds the corner and enters the small opening 103 and a component ~~which~~ that excites an SPP wave propagated in a lower plane of the thin metal film 102 by a downward ~~escaping~~ escape of near-field light are increased, so that a light amount of transmitted light 106 is generated by scattering of these SPP waves on the lower surface side of the small openings 103.--

Please amend the paragraphs at page 16, line 12, to page 17, line 14, as follows:

--As shown in Figure 3, the spectrum is changed by the reaction. This is

because an effective dielectric constant εs as seen from the boundary surface of the sensor material 104 with the thin metal film 102 is changed by a change in the thickness of the film of the sensor material 104 on the thin metal film 102 or a change in the dielectric constant of the sensor material 104 per se due to the reaction between the sensor material 104 and the specimen. For this reason, as is apparent from the ~~above~~ above-described equation (1), the wavelength λsp of the excited SPP wave is changed. By this change, the position of a resonance peak of the transmitted light intensity spectrum is changed as shown, for example, in Figure 3 ~~as an example~~.

Such a change in position of the resonance peak may be determined by, e.g., causing light with a board wavelength spectrum width to enter the sensor medium as incident light and detecting a spectrum shape through a spectroscope. Further, it is also possible to detect a change in transmitted light intensity as indicated by a left-hand (upward) arrow in Figure 3 by irradiating the sensor medium with monochromatic light with a wavelength somewhat shifted from a center wavelength of the resonance peak, i.e., the wavelength of SPP wave, as shown by a wavelength $\lambda 0$ in Figure 3. In the latter case, a detection apparatus becomes compact since the need for the spectroscope is eliminated.

Examples of the sensor material causing the ~~above~~ above-described reaction may include:--

Please amend the paragraphs at page 17, line 24, to page 20, line 7, as

follows:

--Such a sensor material may be ~~those~~ that causing a change in the effective dielectric constant when viewed from the interface of the sensor material with the thin metal film, such as a film thickness change or a refractive index change, through the reaction between the sensor material and the specimen, and may include materials ~~which~~ that can be used in a chemical sensor including biosensors, such as an enzyme sensor, a microbial sensor, an ~~organella~~ organelle sensor, a tissue sensor, an immunosensor, an enzyme immunosensor, and a biochemical affinity sensor.

In the ~~above~~ above-described structure of the sensor medium, the SPP waves propagated at an upper surface of the thin metal film in an in-plane mode have the same phase resonance-~~enhancedly~~ enhanced to increase their amplitudes, thus being concentrated at the small openings. Accordingly, the transmitted light generated by scattering of the incident light at a lower portion of the small openings principally comprises a component attributable to the SPP waves propagated along the upper surface of the thin metal film in an in-plane mode over a longer distance, compared with a component of light directly incident on and transmitted along the small openings ~~and transmitted therealong~~. The SPP waves are accompanied ~~with~~ by a change in the dielectric constant or thickness of the sensor material, i.e., a change in the wavelength depending on a degree of a reaction of the sensor material with the specimen, at the time of propagation along the interface between the thin metal film and the sensor material. Accordingly, it is possible to selectively detect the component attributable to the SPP waves having

information on the degree of a reaction of the sensor material with the specimen by detecting the ~~above~~ above-described transmitted light. As a result, it becomes possible to ~~realize~~ achieve a high sensitivity detection ~~at a high sensitivity~~.

Further, in the case where a circumferential length of a thin metal film portion between adjacent two openings is a substantially integral multiple of wavelength of the SPP wave, an SPP wave ~~which~~ that is ~~once~~ propagated once on the lower surface side of a thin metal film portion after being passed through a small opening and then returned to the upper surface side of the thin metal film portion through an adjacent small opening is in phase with an SPP wave propagated at the upper surface of the thin metal film portion in an in-plane mode, so that a height of the resonance peak in a transmitted light intensity spectrum shown in Figure 3 as an example is further increased, but a width thereof becomes ~~narrower~~smaller. As a result, an amount of a change in the quantity of transmitted light ~~quantity~~ with respect to a change in position of the resonance peak due to a reaction of the sensor material with the specimen becomes larger, thus further improving ~~a~~ the sensitivity of the sensor.

Next, the ~~above~~ above-described circumferential length will be described with reference to Figure 4.

Referring to Figure 4, a propagation path of an SPP wave, which is propagated around a thin metal film portion through adjacent small openings, is indicated by a dotted line with arrows.

~~In~~ Figure 4~~, such a state that~~ shows the SPP wave ~~is propagated~~ propagating

around the thin metal film portion in a clockwise direction indicated by the arrows ~~is shown~~. However, there is similarly present an SPP wave, which is propagated in a counterclockwise direction.--

Please amend the paragraph at page 20, lines 20-26, as follows:

--Of these lengths, effective lengths of the portion A401 and the portion C403 can be determined from the ~~above~~ above-described equation (1) by substituting dielectric constant values of the sensor material and the transparent substrate material for εs, respectively, in ~~the~~ equation (1), while taking their layer (film) thicknesses into consideration.—

Please amend the paragraph at page 21, lines 8-11, as follows:

--In order to provide the circumferential length ~~which~~ that is substantially equal to an integral multiple of the wavelength of the SPP wave, a thickness t of the thin metal film may be adjusted.--

Please amend the paragraph at page 22, lines 16-26, as follows:

--Referring to Figure 5, the chemical sensor apparatus includes a tungsten lump 501, a collimator lens 502, a sensor medium 503, and a spectroscope 504. In the figure, ~~while~~ light emitted from the tungsten lump 501 is changed to substantially parallel

light by the collimator lens 502 to enter the sensor medium 503. Transmitted light passed through the sensor medium 503 is caused to enter the spectroscope 504 to be spectrum-separated and is detected by a multi-channel analyzer 505, whereby spectrum information is obtained.--

Please amend the paragraph at page 23, line 27, to page 24, line 3, as follows:

--First, a quartz substrate 601 is prepared (Figure 6(a))~~, on the quartz substrate 601, a~~. A 50 nm-thick metal film 602 is formed ~~through~~ on the quartz substrate 601 by sputtering (Figure 6(b)).--

Please amend the paragraph at page 25, line 19, to page 26, line 2, as follows:

--In this embodiment, a shape of an array of the small opening pattern may, e.g., be ~~those~~ that of the slit opening array shown in Figure 2(a) and the two-dimensional small opening array shown in Figure 2(b). As the two-dimensional small opening array, in addition to the one having a rectangular (square) lattice with a pitch~~,~~ shown in Figure 2(b), which is substantially equal to a wavelength of the SPP wave, it is possible to use one having a triangular lattice with a pitch substantially equal to ~~a~~ the wavelength of the SPP wave.--

Please amend the paragraphs at page 26, line 9, to page 27, line 4, as follows:

--As shown in Figure 8(a), a small opening 802 is provided at a center of a thin metal film 801. In a portion surrounding the center, a small uneven structure array 803 having a pitch (spacing), which is substantially equal to a wavelength of the SPP wave, is provided.

The small uneven structure array 803 may be one wherein ~~around the small opening 802~~, a concentric small uneven array 804 ~~is disposed~~ (Figure 8(b)) or ~~one wherein around the small opening 802,~~ a two-dimensional small uneven array 805 (Figure 8(c)) is disposed around the small opening 802~~(Figure 8(c))~~.

By disposing the small uneven array around the small opening as described above, it is possible to reduce an influence of direct light, which directly passes through the small opening without being propagated along the interface between the thin metal film 801 and the sensor material 104 in the form of an SPP wave. Further, the SPP wave propagated along the interface between the thin metal film and the sensor material is concentrated in the small opening and passes through the small opening, so that it becomes possible to improve an S/N ratio for signal detection.--

Please amend the paragraph at page 27, lines 10-14, as follows:

--As shown in these figures, a fine metal particle array 902 is disposed on a transparent substrate 901 in a two-dimensional direction with a pitch, which is substantially

equal to a wavelength of an SPP wave.--

Please amend the paragraph at page 27, line 21, to page 28, line 11, as follows:

--A mechanism of propagation of the SPP wave in the fine metal particle array may be such that an SPP wave (localized plasmon) propagated along one fine metal particle is scattered at an end portion to excite an SPP wave~~,~~ propagated along an adjacent fine metal particle, which is also scattered at an end portion, and such that an SPP wave propagated along a periphery of one fine metal particle excites an SPP wave propagated along a periphery of an adjacent fine metal particle by an interaction between the one fine metal particle and the adjacent fine metal particle. In this embodiment, a circumferential length of fine metal particle is substantially equal to an integral multiple of a wavelength of the SPP wave, so that it becomes possible to increase a strength of the SPP wave propagated along the periphery of fine metal particle. For this reason, the propagation of the SPP wave on the basis of the latter mechanism is increased.--

Please amend the paragraph at page 28, lines 16-23, as follows:

--Referring to Figure 10, a thin metal film 1002 is provided on an upper surface of the prism 1001~~,~~ ~~a thin metal film 1002 provided~~ with a fine metal particle array, a small opening array, or a small uneven structure array~~,~~ and is covered with a sensor material 1004. In this embodiment, the array of the fine metal particle, small opening or

small uneven structure has a pitch, which is substantially equal to a wavelength λsp of the SPP wave.--

Please amend the paragraph at page 28, line 26, to page 29, line 7, as follows:

--In order ~~that~~ for a spacing~~,~~ between adjacent wavefronts of incident light 1003, defined by the upper surface of the prism 1001 (a length between adjacent wavefronts along the upper surface of the prism 1001), ~~can~~ to be substantially equal to a pitch of the array of fine metal particles, small openings or small uneven structure, a wavelength λ and an incident angle θ of the incident light 1003 are adjusted to satisfy:--

Please amend the paragraph at page 29, line 14, to page 30, line 1, as follows:

--In this embodiment, detection of a signal may be performed by measuring a spectrum distribution of reflected light 1004 through a spectroscope or by detecting an intensity of reflected light ~~with the use of~~using monochromatic light having at least one wavelength as the incident light. It is also possible to detect a deviation in peak position in an incident angle (θ)-dependent curve of the reflected light intensity by gradually changing the incident angle θ of incident light in a ~~small~~ narrow range. This has a structure similar to that of a surface plasmon resonance (SPR) sensor according to the Kretschmann

configuration ATR (attenuated total reflectance) method. By the combination of this structure with the periodic structure of the SPP wave, high sensitivity detection is ~~realized~~achieved.--

Please amend the paragraph at page 31, lines 5-15, as follows:

--In the sensor apparatus, e.g., light fluxes passed through the small opening array A (1102) and the small opening array B (1103), which have the same shaped pattern, are caused to pass through band-pass filters having different wavelengths and compared with each other, or the sensor medium is irradiated with two monochromatic lights having different wavelengths to compare resultant transmitted light intensities of the two monochromatic lights, whereby it is possible to obtain relative spectrum information ~~which~~ that does not ~~dependent~~ depend on the irradiated light intensity.--

Please amend the paragraph at page 31, line 27, to page 32, line 9, as follows:

--Similarly, ~~sensor materials~~ different in kind sensor materials are disposed in the openings of the small opening arrays A (1102) and B (1103) having the same shape pattern and light fluxes passed through the respective small opening arrays are detected independently, whereby it is possible to obtain ~~a plural~~plural pieces of sensing information at the same time. Further, by effecting a relative comparison therebetween, it becomes possible to perform high sensitivity detection by differential detection.--